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Shape of the Atomic Nucleus

RECENT WORK carried out at the Bureau shows that the energy dependence of the nuclear photon-absorption cross section can be directly related to the shape of the atomic nucleus.[1] This approach to the determination of nuclear shapes developed out of investigations of the interactions between high-energy electromagnetic radiation and matter. One such interaction is the nuclear photoeffect—the absorption of high-energy photons by the nucleus. Recent measurements of the total nuclear absorption cross section—the probability that photons will be absorbed—indicate that the cross-section curve depends in part on the intrinsic nuclear quadrupole moment. Classically, this dependence means that the absorption of high-energy electromagnetic radiation by the nucleus is influenced not only by the finite size of the nucleus but also by its shape.

The finite extent of the nuclear charge distribution was originally demonstrated by the alpha-particle scattering measurements made by Lord Rutherford in the 1920's. Probably the first suggestion that this charge distribution lacked spherical symmetry was made in 1944 by Brix and Kopfermann to explain irregularities they had observed in isotope shifts for some atomic spectral lines.[2] Soon after this, departures from the interval rule for atomic hyperfine structure were explained by postulating a deformation of the nuclear charge distribution. At present, information about this deformation is also being obtained from nuclear spectroscopy (measurement of absolute electric quadrupole transition rates and the energy of nuclear rotational energy states); high-energy electron scattering measurements; and spectral studies of μ-mesonic atoms. However, quantitative values for the nuclear charge deformation obtained from these experiments depend also upon detailed knowledge of either atomic- or nuclear-wave functions. On the other hand, the recent cross-section measurements, which were made by members of the Bureau's high-energy radiation group, can be correlated directly with the intrinsic nuclear quadrupole moment by the following rather simple classical picture.

In the classical limit, the atomic nucleus may be thought of as a figure of revolution with well-defined

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Neutron Physics Research at NBS

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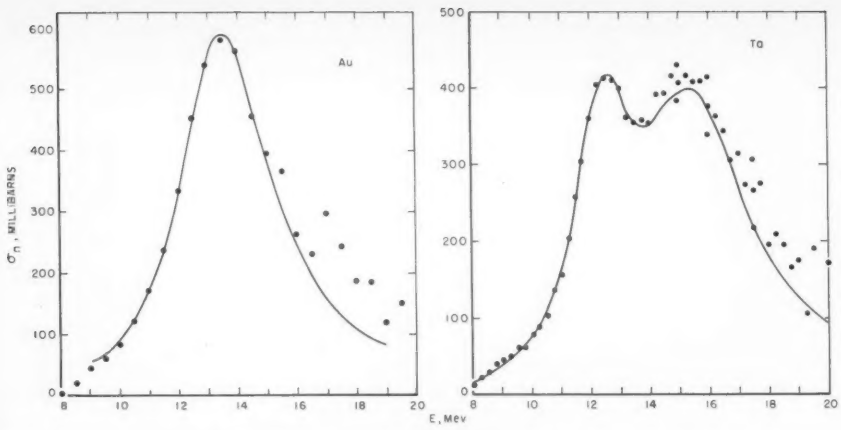
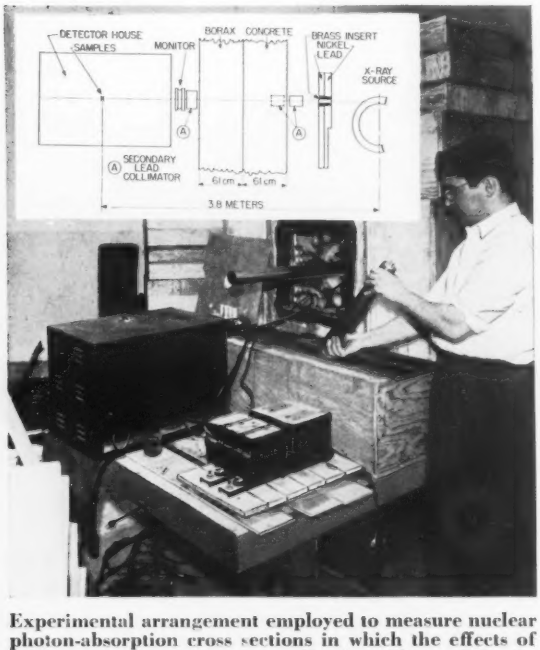


Comparison of the photoneutron production cross sections for gold (Au) and tantalum (Ta). Gold, known to have a small nuclear deformation, displays only a broadening of the giant resonance. On the other hand, the giant resonance of tantalum, known to have a highly deformed nucleus, is split into two resonances.



Experimental arrangement employed to measure nuclear photon-absorption cross sections in which the effects of nuclear deformation are immediately evident. Scientist is assembling detector housing which contains the samples to be bombarded with betatron-produced X-rays. *Insert:* Schematic diagram of the experimental arrangement.

edges. Its mean radius is given by $R=R_0A^{1/3}$, where R_0 is a constant and A is the mass number of the nucleus. In this limit, for a uniformly charged nucleus, the static quadrupole moment is defined by $Q_0=\frac{2}{5}Z(a^2-b^2)$, where a and b are the half axes and Z is the nuclear charge. A classical model which has been successful in predicting many nuclear properties, particularly with respect to the nuclear photoeffect, pictures the nucleus as comp essible neutron and proton fluids contained within rigid boundaries. The electric dipole absorption of electromagnetic radiation by such a nucleus takes place primarily in a single resonance line (the giant resonance) whose energy is inversely proportional to the nuclear radius of a spherical nucleus. It was pointed out by Danos [3] and Okamoto [4] that such a model implies that the giant resonance for the absorption of unpolarized photons by an unalined, deformed nucleus will split into two resonances, one associated with each of the half axes of the nucleus. This prediction has now been experimentally confirmed in some detail at the Bureau.

The experiment consisted in determining the photoneutron production cross section for two nuclei which were known to be highly deformed (terbrium-159 and tantalum-181) and for one known to have only a small deformation (gold-197). These cross sections were obtained from an analysis of the measured neutron yield curves for the three nuclei. A photoneutron yield curve is obtained by bombarding a sample with betatron-produced X-rays and measuring the yield of neutrons as a function of the upper energy limit of the X-ray spectrum. In order to obtain a statistically significant cross section from such a yield curve, it is necessary that statistical uncertainties be very small. To fulfill this requirement, 0.5- to 1.2-million neutron counts were recorded at each significant point on the neutron yield curve; the yield was measured every 0.5 Mev from 7 to 20 Mev.

The resulting photoneutron production cross sections all showed effects of nuclear deformations, as predicted. The giant resonances for Tb and Ta were split into two resonances while that for Au was merely broadened. The quadrupole moments evaluated from these data are in very good agreement with the best previously determined values, demonstrating the applicability of this approach.

[1] Photoneutron yields in the rare earth region, *by E. G. Fuller, B. Petree, and M. S. Weiss, Phys. Rev.* **112,** *554 (Oct. 15, 1958)*; Splitting of the giant resonance for deformed nuclei, *E. G. Fuller and M. S. Weiss, Phys. Rev.* **112,** *560 (1958)*.
[2] *Z. Physik* **126,** *344 (1949)*.
[3] *Bull. Am. Phys. Soc.* **[2],** *No. 1, 135 (1956)*.
[4] *Progr. Theoret. Phys. (Kyoto)* **15,** *75 (1956)*.

Evaluating Lens Distortion—Two Methods Compared

THE TWO METHODS generally used today to measure lens performance give better results than previously believed possible, according to a Bureau study partially supported by the U.S. Air Force.[1] In a series of tests on the same lens, the values for distortion derived either visually or photographically were precise to within ± 4 μ. These limits of error are substantially better than earlier permissible limits of ± 20 μ. The experimental results are expected to lead to increased accuracy in calibrating both the cameras and lenses used in photogrammetry.

Since the advent of aerial mapping from photographs, the radial distortion in the focal plane of photographic objectives (cameras and lenses) has been intensively studied. The magnitude of this distortion is a measure of the degree of accurate reproduction on an enlarged scale of the photographed scene. Lenses are consequently being developed to give ever-decreasing values for distortion in order to increase the reliability of the data derived from aerial photographs.

To evaluate lens performance, several methods have been followed by testing laboratories, but the two most frequently employed are the visual method using a nodal slide bench, and the photographic method using a precision lens-testing camera. However, somewhat inconsistent values have been observed occasionally on the same lens measured at different laboratories by either one of the two methods. Since both kinds of equipment are maintained at the Bureau for special types of calibrations, the present study was undertaken by F. E. Washer, W. P. Tayman, and W. R. Darling to determine the accuracy of the two methods.

The nodal slide bench used for the tests, although constructed 30 years ago, is still regarded as a precision instrument. It consists of a collimator, a nodal-slide lens holder, and a micrometer microscope. When the lens is carefully alined in the holder, the axial image formed of the target's illuminated reticle coincides with the object plane of the viewing microscope. The distortion present in a lens may then be evaluated by shifting the microscope laterally from one position to another, and comparing the results thus obtained.

The precision lens-testing camera is one of the earliest successful devices developed to measure lens performance photographically. The testing equipment includes the camera mounted on a rotating carriage between a viewing microscope and a lens holder. The lens holder is at the center of convergence of an array of 10 collimators arranged in a fan shape to cover an angle of 45°. Resolution charts are used as reticles for the collimators.

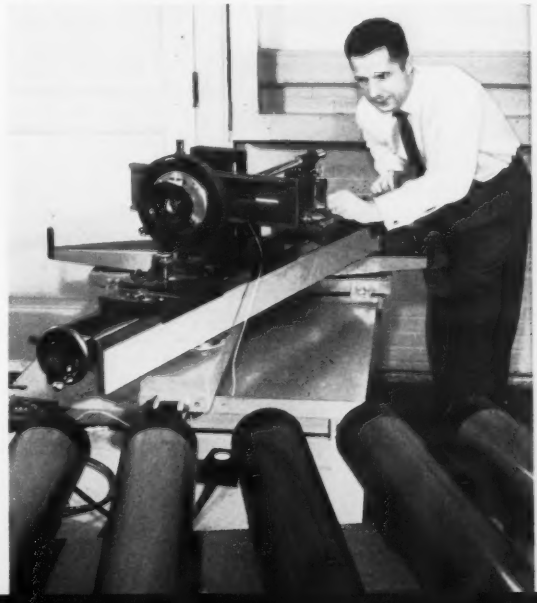
The lens under test is mounted in the holder and alined with the collimator in the 0° position. The carriage is rotated until the camera is aimed at one of the extreme collimators and a negative is made. The carriage is then rotated until the camera is aimed at the collimator at the opposite extreme and a second negative is made. Measurements on the photographs obtained from these two positions are used to evaluate the magnitude of radial distortion present.

In the present experiment, the lens tested had an equivalent focal length of 150 mm, with values of distortion referred to the equivalent focal length ranging from $+110$ to -110 μ. In comparing the values of distortion found by both methods, all values were referred to a calibrated focal length. Thus the positive maximum distortion value in each case was equal in magnitude to the negative minimum distortion value.

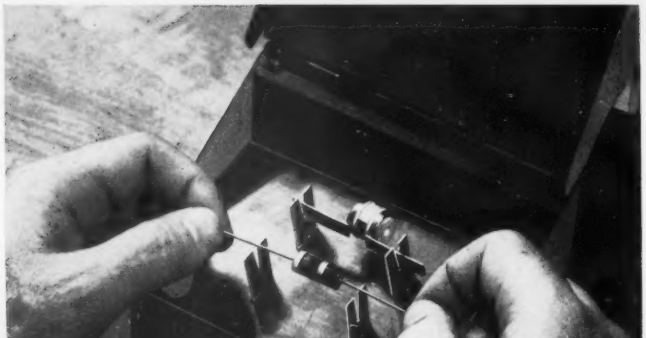
Nearly identical results were obtained with the two methods. These findings indicate that when proper care is exercised, the values obtained by either method need not depart from the common average by more than ± 5 μ. In the course of the investigation it was noted that the values derived by the photographic method could be adversely affected by plate curvature, warpage of the plates or differential plate tipping; improper alinement of the collimators; errors in the angles separating collimators; and errors in plate measurements. A number of calibrations on the same lens with the nodal slide method showed no systematic error present when special precaution was taken in alinement adjustments.

[1] *For further technical details, see* Evaluation of lens distortion by visual and photographic methods, *by Francis E. Washer, William P. Tayman, and Walter R. Darling, J. Research NBS* **61**, 509 (1958) RP2920.

Precision lens-testing camera used to measure lens distortion. The lens holder, camera and viewing microscope are supported on a rotating carriage that can be aimed at any one of 10 collimators, several of which appear in foreground.



Measurement of Resistor Noise

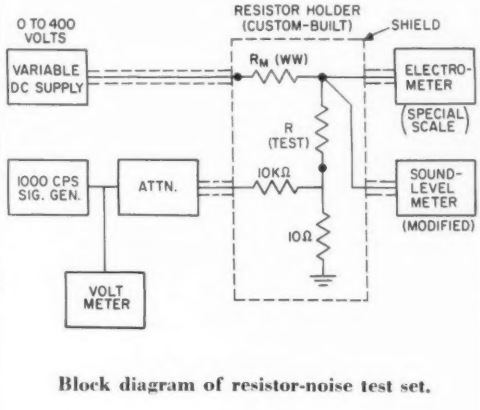


THE National Bureau of Standards has developed a method to evaluate the noise quality of fixed composition resistors [1] for the Navy Bureau of Ships and the Navy Bureau of Aeronautics. With this technique, the noise quality is determined by measuring the increase in the mean fluctuation voltage at the terminals of a sample resistor when direct current is passed through the resistor. Two meters in the test set, one indicating average noise and the other the applied d-c power, can be read in decibels for readily computing an index of noise quality or conversion gain. The method was developed by G. T. Conrad, Jr., of the engineering electronics laboratory as part of a broader program concerned with the standardization of test methods for electronic components.

All resistors exhibit a certain amount of noise which appears as a fluctuating voltage at their terminals. The spectral density of their thermal noise depends only upon temperature and resistance and is independent of frequency. When direct current is passed through a granular-type resistor, an additional fluctuating voltage, called current noise, appears at the resistor terminals. The spectral density of the current noise depends upon the type of resistive material, the fabricating process, and the structure, size, and shape of the resistor. In general, the spectral density is also a function of frequency. For a typical resistor at 1,000 cps, the current-noise spectral density may be as much as 1,000 times the thermal-noise spectral density.

Ordinarily, the circuit design engineer is not concerned with thermal noise, since its voltage level is relatively low. In many cases, current noise is not important either, although it can be as large or larger than thermal noise. However, in some extremely sensitive low-frequency circuits, such as high-gain audio amplifiers and infrared detectors, current noise becomes important because it could mask the signal. Thus the circuit designer must know, quantitatively, how much this phenomenon may affect the operation of his equipment. As there has been no reliable, reproducible method of estimating current noise, the Bureau undertook the development of a noise test set that would give the electronics engineer technical information on resistors in a form suitable for these special applications. The resulting test set is now being considered as a military standard.

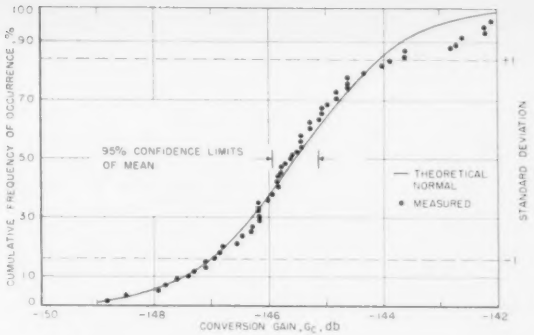
The noise test set consists principally of modified, readily available laboratory measuring equipment, all



Block diagram of resistor-noise test set.

Above: **Resistor to be tested is placed in terminals of resistor box and is electrically shielded when the cover is closed.**

Distribution of conversion gain values of 58 "identical" resistors shows typical agreement between the cumulative distribution of measurements on the resistor samples, and a theoretical normal distribution curve. The theoretical curve was drawn so that its mean and standard deviation values equal those calculated from the measurement data. The mean value indicates the average noisiness of the group, while the standard deviation indicates the variability between measurements.



of which can be conveniently assembled and operated on a small desk top. A shielded box holds the resistor under test; normally a shielded room is not necessary. The equipment permits rapid measurement of fluctuation voltage at the resistor terminals without interference from power-line hum, broadcast stations, or other sources. The set accommodates resistors over the range of at least 100 ohms to 20 megohms, and also provides an adjustable d-c power source having a maximum test voltage of approximately 400 v with currents up to 100 ma.

The test set measures conversion gain, the quantity recommended for evaluating noise quality. Conversion gain is defined as the ratio of available current-noise power to applied d-c power, expressed in decibels. It is a measure of the efficiency with which a resistor converts applied d-c power to noise—the more efficient the conversion, the poorer the noise quality.

The center frequency of the pass band used in measuring conversion gain is 1,000 cps. This frequency, although arbitrarily selected, has proven to be a reasonable choice insofar as instrumentation is concerned. Since current noise varies inversely with frequency, measurement of conversion gain would be expected to vary in a similar manner.

Six of these noise test sets have been constructed and delivered to the Navy. However, before delivery, a series of experiments was performed to determine how well one set could reproduce the measurements obtained from any other set. Results indicate that the variation between sets is less than 1 db. The experiments were performed with resistors in the range from 1,000 ohm to 1 megohm.

[1] *For additional technical information, see* Noise in composition resistors, *by G. T. Conrad, Proc. Nat. Electronics Conf.* **10** *(February 1955).* Noise measurements of composition resistors, *by G. T. Conrad, IRE Transactions on Component Parts* **PGCP–4** *(1955).* A proposed current-noise index for composition resistors, *G. T. Conrad, IRE Transactions of the Professional Group on Component Parts* **CP–3,** *No. 1 (1956).*

HERBSTREIT RECEIVES IRE AWARD

JACK W. HERBSTREIT of the Bureau's Boulder Laboratories has been named by the Institute of Radio Engineers to receive the 1959 Harry J. Diamond Memorial Award, regarded as one of the highest honors a government engineer can receive in the field of radio and electronics. The award was named for the late organizer and first chief of the Bureau's Ordnance Development Laboratory, which is now operated by the Department of the Army as the Diamond Ordnance Fuze Laboratories.

Mr. Herbstreit, Assistant Chief of the Engineering Division of the Central Radio Propagation Laboratory, will formally receive the award at the annual banquet during the IRE convention in New York next March. The award will specifically cite his leadership and original contributions in the field of radio propagation.

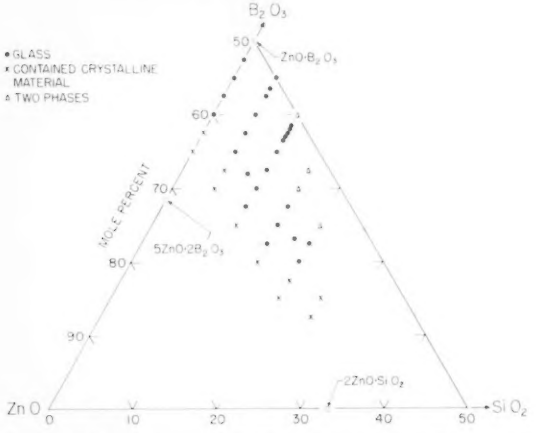
Born in Cincinnati, Ohio, Mr. Herbstreit received his degree in electrical engineering from the University of Cincinnati in 1939. Prior to coming to the Bureau, he was with the Federal Communications Commission and the Office of the Signal Officer, Department of the Army.

Mr. Herbstreit joined the Bureau in 1946. He became Chief of the Tropospheric Research Section in 1949, and was appointed to his present position in 1956.

A senior member of the IRE since 1945, Mr. Herbstreit served one year as Vice Chairman of the Denver section, and one year as its Chairman. His other professional memberships include Tau Beta Pi, Eta Kappa Nu, Phi Eta Sigma, Scientific Research Society of America, the American Association for the Advancement of Science, and the Engineering Society of Cincinnati. He is a member of Commission II of the International Scientific Radio Union, and is the NBS representative on the Radio Technical Committee for Aeronautics.

HEAT-RESISTANT ZINC BOROSILICATE GLASSES

THE GLASS-FORMING region of the zinc borosilicate system has been investigated in work [1] conducted for the U.S. Air Force. All of the glasses that were prepared had low thermal expansions—in some cases as low as those of the well-known heat-resistant-type glasses used for laboratory and household ovenware. As the zinc borosilicate glasses can be melted at moderate temperatures, they lend themselves to the production of glasses of an optical quality which is extremely difficult to obtain with the high-melting, commercial heat-resistant glasses.



Composition diagram indicating the glass-forming region of the zinc borosilicate system.

Glass that can resist both high temperature and thermal shock and yet maintain good optical quality is needed for glazing windows in supersonic aircraft so that visual and photographic observations can be made with a minimum of distortion.

A number of properties, including tensile strength, thermal expansion, elastic modulus, thermal conductivity, density, and specific heat, affect the thermal shock resistance of a glass. However, thermal expansion and Young's modulus are two of the factors that can be accurately determined and which should give an indication of the relative thermal shock resistance of different glasses.

As a zinc borate glass had been reported to have a low thermal expansion and other extreme properties, E. H. Hamilton, R. M. Waxler, and J. M. Nivert, Jr., surveyed the composition range of the zinc borate and zinc borosilicate glass systems. Of the 42 different compositions that were melted, 26 produced homogeneous glasses, the compositions of which were within the following limits in mole percent: 50 to 60 of zinc oxide; 20 to 50 of boric oxide; and 0 to 20 of silica. Very fluid melts were obtained between 1,100° and 1,300° C, a factor that aided materially in producing homogeneous melts.

The following properties of these glasses were then investigated: Sag point; liquidus temperature; refractive index; modulus of elasticity; thermal expansion; chemical durability; and surface devitrification.

The sag point is the temperature above which a fiber of glass sags under its own weight, and indicates the temperature at which the glass will deform. The sag points of the zinc borosilicate glasses ranged from 585° to 665° C, which is the approximate temperature range of the sag points of most commercial borosilicate and silicate glasses.

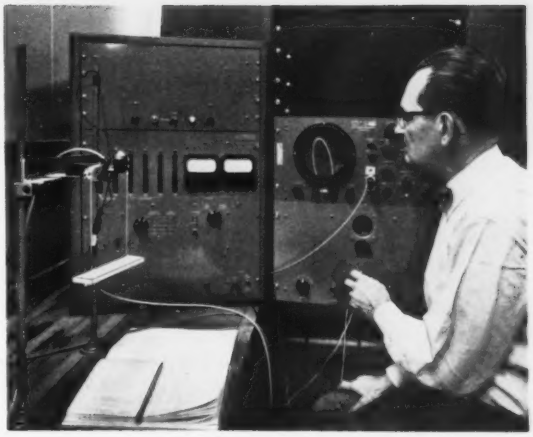
All of the clear glasses had liquidus temperatures between 950° and 1,000° C. Glasses containing less than 55 mole percent ZnO were characterized by the presence of thin films on the top surface of the cast specimen. These films varied in thickness and produced interference colors in reflected light. The refractive indices of the glasses ranged from 1.6409 to 1.6798.

Modulus of elasticity was obtained for four of the glasses by determining the resonant frequency of specimens approximately $\frac{5}{8}$ in. by $1\frac{1}{2}$ in. by $\frac{1}{8}$ in. The glasses had Young's modulus values of 836 to 860 kilobars [2] (12.1×10^6 to 12.5×10^6 lb/in.^{2}), and Poisson's ratios of about 0.3, both of which are higher than those reported for common optical glasses.

Between 25° and 100° C, the linear coefficients of thermal expansion for the glasses ranged from 3.2×10^{-6} to 3.8×10^{-6} per deg C. They were thus com-

Linear thermal expansion of a glass specimen in the furnace (right) is determined by an interferometric method.

The resonant frequency of a glass specimen (lower left) is being determined for use in calculating Young's modulus. The frequency is indicated by the counter on the left. The oscilloscope (right center) indicates when the resonant frequency is reached.



parable to the thermal expansions of some commercial heat-resistant glasses. Between 100° and 400° C. the average coefficients were higher, 5.0×10^{-6} to 5.3×10^{-6}. These values, however, are considerably lower than those for most sheet and plate glasses, which are between 7.0×10^{-6} and 10.0×10^{-6}.

The chemical durabilities of three glasses were determined in solutions buffered at different *p*H values. The addition of SiO_2 to the zinc borate glasses did not improve their resistance to acids but did improve their resistance to strong alkali. The chemical tests indicated that the glasses should be serviceable in contact with water or neutral solutions.

During annealing, the two-component ZnO–B_2O_3 glasses developed a dull appearance on their exposed surfaces. The amount of this surface devitrification varied with the time and temperature of heat treatment. The three component glasses, containing as little as 5 mole percent SiO_2, maintained a brilliant transparent surface during annealing.

Glasses with the low thermal expansions shown by the zinc borosilicate glasses should be more resistant to thermal shock than commercial plate and sheet glasses. The glasses show possibility of being further developed to provide greater thermal-shock resistance by adding other components such as Al_2O_3, CaO, MgO, SrO, ZrO_2, and TiO_2.

[1] *For further technical details, see* Properties of zinc borosilicate glasses, *by E. H. Hamilton, R. M. Waxler, and J. M. Nivert, Jr., J. Research NBS* **62**, 59 (1959) *RP2930.*

[2] *One kilobar is equivalent to* 1×10^9 *dynes/cm*^{2}.

Ad Hoc Science Committee to Review NBS Program

THE National Bureau of Standards and other scientific agencies of the U.S. Department of Commerce will be the subjects of a study by a special committee of scientists and research administrators appointed by the National Academy of Sciences-National Research Council.

The announcement of the study by Lewis L. Strauss, Secretary of Commerce, and Dr. Detlev W. Bronk, President of the Academy-Research Council, said that the Committee will study the requirements of science and industry for services of the type the Department of Commerce can provide, new or improved means of meeting these requirements, and assured methods of relating the Department's programs to the improving techniques afforded by scientific and technological progress.

Dr. Mervin J. Kelly, Chairman of the Board of the Bell Telephone Laboratories, will head the group.[1] Other members of the Committee are Professor Horace R. Byers, Department of Meteorology, University of Chicago; Dr. H. A. Leedy, Armour Research Foundation, Illinois Institute of Technology, Chicago; Dr. C. Guy Suits, Vice President and Director of Research, General Electric Co. Research Laboratories, Schenectady, New York; Professor Abel Wolman, The Johns Hopkins University, Baltimore; Dr. Augustus Kinzel, Vice President (Research), Union Carbide Corp., New York City; Dr. Michael Ference, Jr., Director of Engineering Staff, Ford Motor Co., Dearborn, Michigan; and Frank W. Herring, Deputy Director for Comprehensive Planning, New York Port Authority, New York City. John C. Green, Director of Commerce's Office of Technical Services, has been named Executive Secretary.

In addition to the Bureau, other Commerce agencies under study include the Bureau of Public Roads, Maritime Administration, Patent Office, Weather Bureau, Coast and Geodetic Survey, and Office of Technical Services. The Committee will spend several months reviewing the operations of these agencies, and plans to submit a report to the Secretary of Commerce about June 1, 1959.

The National Academy of Sciences-National Research Council is a private organization of distinguished scientists dedicated to the furtherance of science and its application to the general welfare. Under its Congressional Act of Incorporation it is called upon to advise the Federal Government, upon request, on all matters of scientific and technical interest.

[1] *In 1953, an Ad Hoc Committee, also headed by Dr. Kelly and appointed by the Secretary of Commerce, made an evaluation of the NBS role in science and technology in relation to national needs.*

A glass tube containing samples of magnetic recording tape is inserted into a magnetizing coil in preparation for a measurement of remanent flux, part of a suggested basis for specifying tape performance in terms of anhysteretic magnetic properties. Strips of magnetic tape and an empty tube illustrate a typical sample.

Performance of Magnetic Tape

AN INVESTIGATION of the performance of magnetic tape, used in recording the data transmitted by guided missiles and satellites, is being conducted by the Bureau for the U.S. Air Force.[1] The quality of such tape directly influences the usefulness of the recorded information. For this reason, specification limits and quality control are needed in production. Standard methods of measuring the magnetic properties of the tape which will help make such control possible are the goal of the present study.

Although magnetic tape is widely used in recording sound, data recording by this method has not been entirely satisfactory. Failure of the tape to record important data has at times been very costly, wasting time and money, and even destroying irreplaceable data. Because existing test procedures do not adequately measure all properties that affect performance, the danger of tape failure is ever present. To make possible at least a predetermination of quality that will in some measure guarantee tape performance, I. Levine and E. Daniel of the sound laboratories undertook the present investigation of magnetic properties.

It is the usual practice in tape specifications to express the magnetic properties in terms of retentivity and coercivity, measured by a hysteresis loop tracer. However, most telemetry recorders use high-frequency bias during recording, and the hysteretic constants mentioned can give only a rough indication of performance under these conditions. Consequently, separate record and bias current data must also be provided in each tape specification. Such data are purely relative and, moreover, apply only to a specific machine: they cannot be accurately translated to another machine having a significantly different record gap length.

In developing a more useful method of measuring magnetic properties it was necessary to clarify the action of the hf bias. It was found that an anhysteretic method of magnetization provides the key to an understanding of this recording process. Therefore, a simple semiempirical theory was constructed which allows both recording sensitivity and bias for maximum output to be determined from the anhysteretic magnetic properties of the tape in question. The basic properties of a tape are completely specified in terms of three constants: oxide thickness, anhysteretic susceptibility, and critical field strength. The advantage of calculating tape performance in this way is that it provides a flexible method of comparing tapes which is completely independent of any particular recording machine.

The results obtained so far are confined to the long-wavelength performance of a tape under linear operating conditions. However, it should be possible to extend the treatment to short wavelengths by taking into account such factors as separation loss and phase effects. Also it seems likely that nonlinearity in recording can be related to the results of anhysteretic tests.

Measurements are made under conditions simulating as closely as possible those encountered in use. The test sample, a tape of known magnetic area, is anhysteretically magnetized in a solenoid energized with a small direct current and a large alternating current. The former is analogous to the signal and the latter to the bias component of the current through an actual record head. The remanent magnetization in the sample after the currents are reduced to zero is measured by passing the sample through a search coil connected to a fluxmeter. Reduction of the currents to zero takes place in two modes: (1) The gradual reduction of the

Measuring the remanent flux in a sample of magnetic recording tape. Tape (contained in glass tube) is magnetized in the large coil attached to the lower part of the test unit. The tube is then rapidly passed through the smaller search coil and remanent flux is read from the upper part of the unit.

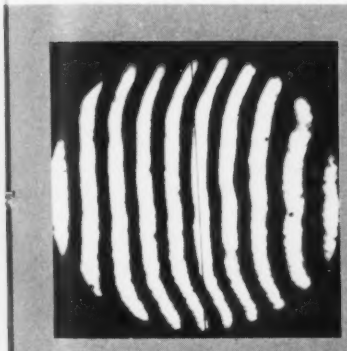
ac to zero before removing the dc; and (2) the simultaneous gradual reduction of ac and dc to zero.

Although the latter mode simulates more closely the action of a recording head, the former is of value in determining the fundamental constants of the anhysteretic process. With the type of reduction first described, the remanent magnetization corresponding to a given small d-c field strength increases as the initial amplitude of the a-c field is increased to about 350 oersteds and remains fixed at a maximum value which is independent of any further increase in a-c field strength. The behavior of a given tape can be expressed in terms of two constants: The anhysteretic susceptibility, which is the ratio of the maximum remanent magnetization at a high a-c field amplitude to the d-c field strength; and the critical field strength, the a-c field amplitude required to achieve half the maximum remanent magnetization.

In practice it is unnecessary to take a whole series of measurements in order to determine the critical field strength. Just two measurements, one in each mode, give sufficient information to calculate both the anhysteretic constants. In calculating the magnetization of the sample, it is necessary to know the thickness of the oxide coating. This may be determined by measuring the over-all thickness of, say, 10 layers of tape, then stripping the coating with a solvent and measuring the 10 layers of backing after allowing time for evaporation.

The chief difference between the action of the solenoid and that of a record head is that the latter does not provide a uniform signal and bias field strength throughout the depth of the coating. The effect of this nonuniformity may, however, be taken into account if the record gap length is known. Calculations of long-wavelength performance may be made which are in good agreement with absolute measurements carried out on an actual recorder. In particular, it is possible to calculate the bias field strength needed to obtain maximum output, and the recorded flux for a given signal field strength obtained under the maximal condition.

[1] Determination of the recording performance of a tape from its magnetic properties, *by I. Levine and E. Daniel, J. Audio Engineering Soc., Preprint No. 45.*



Interferometer for Testing Large Surfaces

A SIMPLE, sensitive interferometer for testing the flatness of large surfaces has been developed.[1] The instrument examines surfaces by producing a set of interference fringes, which is, in effect, a contour map of the test area. Areas of any size can be tested by merely adjusting the angle of incidence of the light on the surface. The width of the area examined at each setting is always equal to the linear aperture of the instrument.

Such an instrument can greatly facilitate the testing of precision flat surfaces such as aircraft fixtures machine ways and layout plates, which must be carefully examined for irregularities. It would not only allow quick checks of surface quality but would also provide a means of production control by locating the spots where added polishing or lapping are required.

Above: **Sample interference fringes obtained with a surface plate interferometer. Pattern represents an area 36 in. long and 1¾ in. wide. It was produced with white light and shows the concavity of a granite surface.**

As the only other known interferometric device designed for investigating large areas [2] is extremely complex, the autocollimator, though less accurate, is usually employed in flatness measurements.

The present instrument for surface plate testing was developed by J. B. Saunders and Franz Gross [3] of the optical instrument laboratories under a program aimed at closer dimensional control of machine-produced parts. The present development, by insuring the flatness of surfaces on which parts are compared, should aid materially in the control of dimensional tolerances.

The principal element of the interferometer is a double-image prism which separates a beam of light into two components. One component is reflected from the test surface to a plane mirror and back. On recombination with the other component, reflected from a plane mirror only, interference fringes are formed which are a measure of surface evenness and flatness.

The fringes that appear in the interferometer eyepiece represent contours of equal elevation. They lie

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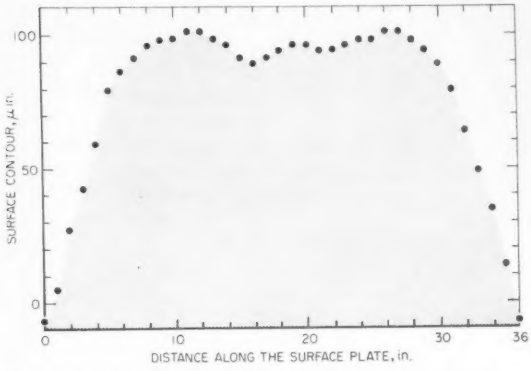
along straight lines if the surface under test is perfectly flat, but are curved if the surface is not flat. Small irregularities which do not affect over-all flatness characteristics produce serrated or ragged fringes. The number of fringes, and therefore the fringe width, is adjustable, but the contour interval thereby represented depends upon the wavelength of the light and the angle of incidence.



Data plotted from interferometric measurements of a 36-in. layout plate. The interferometer permits irregularities as small as 10 μin. to be determined.

In interferometers previously used for measuring flatness, a one-fringe departure from straightness corresponds to a surface departure from flatness of $\lambda/(2\cos\beta)$, where λ is the wavelength of the light and β the angle of incidence. In the present instrument, because light is reflected twice from the test surface, the sensitivity is double that of conventional interferometers, that is, equal to $\lambda/(4\cos\beta)$. Consequently, even though the sensitivity is lowered by increasing the angle of incidence to cover long surfaces, it is sufficiently high for all present requirements.

To test this instrument, a $1\frac{3}{4}$-in. aperture system was adjusted to cover a 36-in. surface, requiring an $87\frac{1}{4}°$ angle of incidence. With light having a wavelength of 0.5876 μ, one fringe corresponds to approximately

Fringes formed in the interferometer eyepiece give an accurate representation of the 36-in. surface under study.

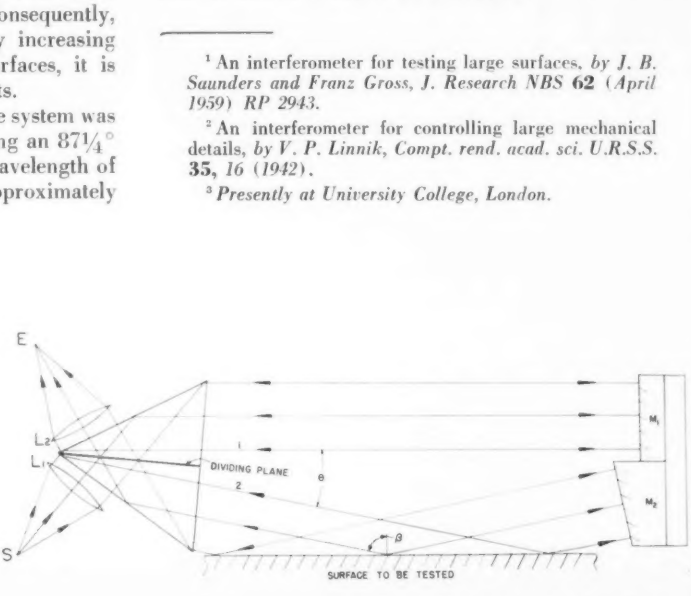
0.0001 in. As an experienced observer can estimate fringes to better than one-tenth of a fringe spacing, surface irregularities of approximately 10 μin. were readily detectable.

Two of the surfaces studied with this instrument were layout plates 36 in. long. One was a granite slab with a dull finish. Since the reflectivity of a surface increases with angles of incidence, this relatively rough surface was tested with a large angle of incidence. Very smooth fringes were obtained. The other surface investigated was a cast-iron plate that had been in use at the Bureau for 40 years. This surface was badly scratched but the interferometer showed that its over-all flatness characteristics were excellent.

[1] An interferometer for testing large surfaces, *by J. B. Saunders and Franz Gross, J. Research NBS* **62** *(April 1959) RP 2943.*

[2] An interferometer for controlling large mechanical details, *by V. P. Linnik, Compt. rend. acad. sci. U.R.S.S.* **35,** *16 (1942).*

[3] *Presently at University College, London.*



Optical system of the interferometer designed by the Bureau. Light from source S is divided into two components. When beam 2, which is reflected from the test surface to plane mirror M_2 and back, recombines with beam 1, which is reflected from plane mirror M_1 only, interference fringes are formed. By adjusting the angle of incidence, surfaces of any length can be studied.

PREPARATION OF MOLYBDENUM CHLORIDES

THE TRI- AND TETRACHLORIDES of molybdenum can now be easily prepared by two convenient methods developed at the Bureau in work partially supported by the Army's Springfield Armory. Both laboratory procedures involve reactions with molybdenum pentachloride, which is commercially available. Good yields are obtained under recommended temperature and pressure conditions.

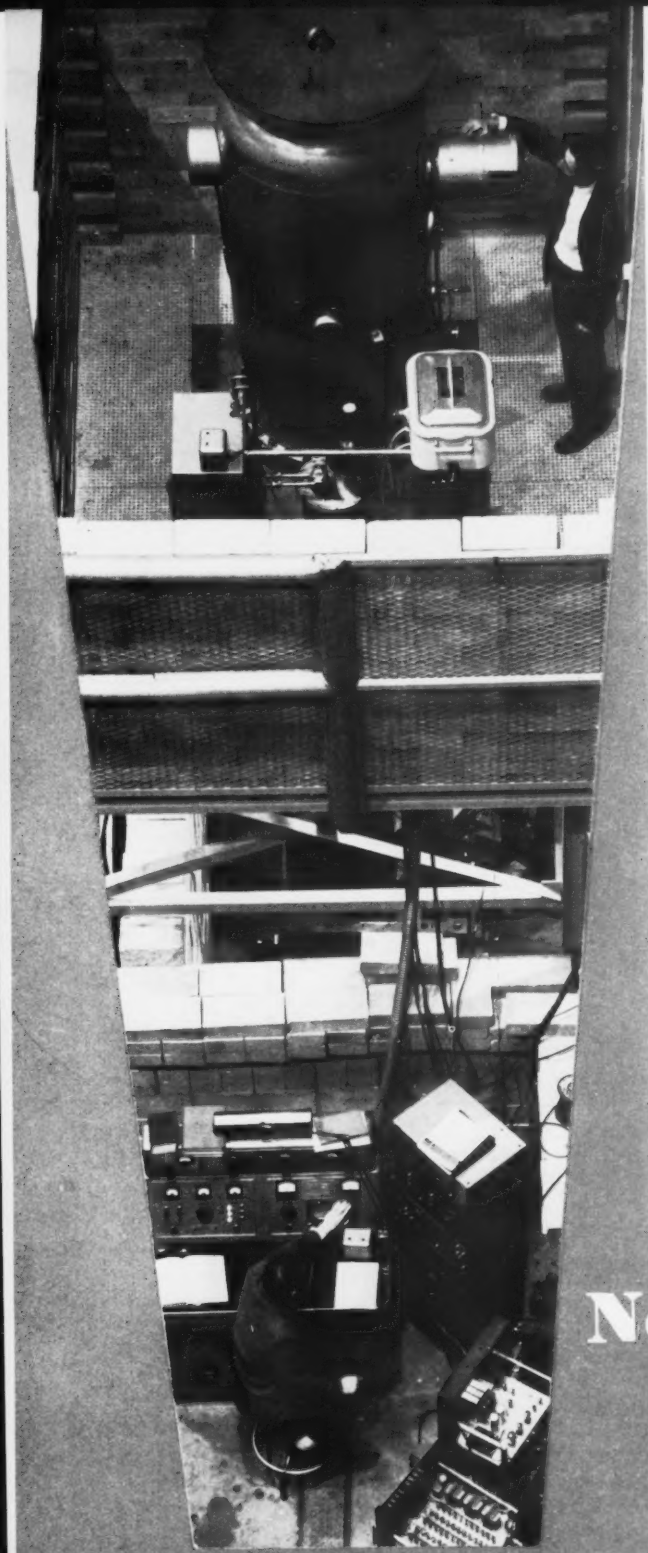
As neither tri- nor tetrachloride can be obtained commercially, laboratory preparation is the only source of these compounds. Previous methods of preparation are inconvenient and time consuming, or else yield an impure product. For example, the reaction between molybdenum pentachloride and hydrogen at a temperature of 250°C at atmospheric pressure gives a 5-percent yield of the trichloride after a period of 12 hr. With the improved method, lower temperatures and higher pressures are used, producing 97- to 98-percent yields of nearly pure material in 12 hr. Since only a few methods are available for preparing the tetrachloride, the newly developed method provides a valuable source of this low-valent molybdenum compound.

The present methods for both chlorides resulted from experimental studies conducted by D. E. Couch and A. Brenner. The trichloride was prepared by reducing the pentachloride with excess hydrogen. Ordinary high-pressure equipment, a 1-liter steel bomb was used for 50- to 500-g batches. Molybdenum pentachloride inside the bomb was treated with hydrogen at pressures from 100 to 1,750 psi while the bomb was heated in an external resistance-type furnace to temperatures ranging from 25° to 275° C. The trichloride was obtained in satisfactory yields as long as excess hydrogen was present, temperatures were between 125° and 194° C, and pressures were 100 psi and above.

The tetrachloride was prepared from a finely ground mixture of molybdenum trichloride and molybdenum pentachloride. A glass tube containing about 5 g of the mixture was sealed in an inert atmosphere and placed inside a steel bomb. Both were then heated in a furnace. A 2:1 mole ratio of pentachloride to trichloride gave the best results with respect to reaction time. At 250° C, the reaction was about 97 percent complete in 20 hr. The completeness of the reactions was determined by an assay for molybdenum trichloride based on its insolubility in 1:1 hydrochloric acid.

As chemical analysis of these compounds can be deceiving, X-ray diffraction patterns of various molybdenum chlorides prepared by other methods were compared with those of the tri- and tetrachloride prepared as described above. The X-ray patterns of the trichlorides prepared by hydrogen reduction and by thermal decomposition were identical. The patterns for the tetrachloride obtained from the trichloride-pentachloride reaction showed sharp peaks similar to those obtained with other pure samples of molybdenum tetrachloride. None of the peaks corresponded to those for lower- or higher-valent molybdenum chlorides. Thus, the data confirmed the identity of the reaction products of the newly developed methods, indicating that these methods are satisfactory laboratory techniques.

Molybdenum pentachloride used as a source of the tri- and tetrachlorides is placed inside a steel bomb and hydrogenated at the desired pressure.



Van de Graaff accelerator used in the production of neutrons.

Neutron Physics Research at NBS

THE NEUTRON is an electrically neutral, elementary particle which plays an essential role in many vital nuclear processes. For example, it is the key particle in nuclear fission—a process which is producing a whole new nuclear-energy industry. Understanding the properties of the neutron and the way it interacts with matter is essential not only for this one application but for research into other fields such as controlled thermonuclear power. The effective use of high-energy accelerators and nuclear reactors in atomic and nuclear research also depends upon sufficient information about the neutron, as does the successful application of slow neutrons to the treatment of cancer, a therapy now only in experimental stages.

To aid in the safe and effective use of the neutron, the Bureau established a small program in neutron standards several years ago. As the requirements of research and industry have changed over the years, the emphasis of the program has shifted accordingly. At present, research in this area is carried out by the Neutron Physics Section, established in 1957, under the direction of R. S. Caswell.[1] Attention is being concentrated on the establishment and maintenance of standards of neutron source strength and thermal-neutron flux, studies of neutron penetration and slowing down, measurement of neutron and gamma-ray dose in radiation fields, and investigations of improved neutron detectors.

In recent years, the number of neutron sources in the United States and elsewhere has greatly increased, and the demand for precise measurement of neutron-radiation fields for protection of personnel has correspondingly become much greater. However, detection and shielding are complicated by the fact that neutrons, because they lack electrical charge, have few interactions with matter, particularly with the electrons of atoms. Neutrons, however, do react with atomic nuclei, and must therefore be detected indirectly by means of other particles which result from these interactions. Such particles might be, for example, recoil nuclei from "billiard-ball", or elastic, collisions, or alpha particles ejected from nuclei which have absorbed neutrons.

Although detection equipment and film badges for personnel monitoring are now extensively employed in the areas of accelerators and reactors, there is still need for improvement in measurements of neutron-radiation dose. Such measurements are complicated by the presence of gamma-radiation in all neutron fields. To

make possible more accurate neutron dosimetry, the Bureau has extended its 35-year-old program in X- and gamma-ray dosimetry to handle the problems presented by mixed neutron and gamma-radiation fields.

Accuracy of all neutron measurements is ultimately dependent on the reliability of standards. In line with its basic functions, the Bureau therefore calibrates absolutely and maintains the national standards of neutron source strength and thermal-neutron flux.[2] Laboratory standard neutron sources are calibrated for universities, industrial experimental stations, and other government agencies for use as secondary standards in fundamental nuclear-physics experiments, measurements of nuclear-reactor behavior, problems of neutron-radiation protection, and industrial applications of neutron beams. In addition to source calibration, neutron fluxes in nuclear reactors are calibrated by activating gold or copper foils and counting against foils activated with a standard thermal-neutron flux geometry.

A basic understanding of neutron shielding is needed in designing shields for nuclear reactors and for particle accelerators such as cyclotrons and linear resonance accelerators, where the neutron shielding problem is often an outstanding consideration. Experiments in neutron penetration are carried out by the Bureau to check neutron shielding theories. The theories can then be applied to the design of light-weight, high-efficiency shields for mobile reactors, employed in nuclear-powered aircraft, ships, and submarines. Particularly in the case of the nuclear-powered airplane, the weight of a conventional shield, such as concrete, is prohibitive.

Other experiments are concerned with precise measurements of the neutron "age" in reactor moderator materials such as water and heavy water. The age is a measure of the penetration of neutrons during the slowing down process, and is an important constant for determining the leakage of neutrons from a reactor.

A fundamental approach to neutron problems is the direct measurement of the "neutron cross section"—the probability of a neutron undergoing a certain nuclear reaction with a given nucleus. A program aimed at measuring these interactions is underway.

Neutron Standards

In the late 1940's, two nearly identical radium-beryllium neutron sources were constructed to serve as standards of neutron source strength.[3] Each source consists of a capsule of 1 g of radium in the center of a beryllium sphere, 4 cm in diameter. One source, NBS–1, serves as the national neutron standard. The second source, NBS–2, is loaned to other laboratories to intercompare sources throughout the world. This second standard was recently sent to England and to Sweden for international intercomparisons.

In the past, most national standard neutron sources have been radium-beryllium (α,n) sources, made by mixing a radium-containing powder with beryllium powder. Although these sources have high neutron yields, they are not completely satisfactory because the neutron strength increases with time as radium decays

New low-scatter building has a grating floor and thin metal walls to insure that neutrons observed by detector (left) originate only from the target (right). To minimize neutron scatter, both target and detectors are normally 6 ft above the grating.

to polonium. Any change in state of the mixed powders can lead to a change in neutron emission rate, which is, of course, undesirable in a standard source. The capsule-in-sphere radium beryllium (γ,n) source overcomes this problem as neutrons are produced only by the gamma-rays from radium acting on the beryllium in the spherical shell.

While these photoneutron sources are very well suited for standards, they are inconvenient to work with in some laboratory situations because of large gamma-ray emission. More acceptable laboratory standard sources are plutonium-beryllium (α,n) sources, which have been made available by the Atomic Energy Commission. This type of source, which provides low gamma-ray emission and long half-life, sometimes is used as a working standard at the Bureau.

The NBS standard neutron sources have been intercompared, either directly or indirectly, with the national standard neutron sources of all countries known to maintain sources, including the U.S.S.R. All of these sources are in agreement to within about 2 percent of the international mean value.

The national neutron source has been calibrated absolutely in two different ways. The first, and most tedious, method involved the measurement of a thermal-neutron density in a water tank surrounding the source. In the idealized situation, the water tank is large enough so that it can be assumed no neutrons escape. Each neutron from the source must therefore appear as a thermal neutron somewhere in the tank. By integrating the thermal-neutron density—measured by its effect on a foil calibrated in a known thermal-neutron density—the neutron emission rate of the source is obtained.

The second type of absolute measurement of neutron source strength involves activating a water bath containing manganese sulfate. Neutrons from the source are slowed down in the bath and are captured finally either by manganese atoms or hydrogen atoms. The number of manganese atoms activated is measured by a method which amounts to absolute counting of the induced beta-ray activity of the manganese. The fraction of neutrons lost to hydrogen is estimated either from the measured manganese and hydrogen thermal-neutron absorption probabilities (cross sections) or by changing the concentration of manganese in the bath and comparing activations.

The standard thermal-neutron flux geometry used for calibrating neutron fluxes consists of two symmetrically placed radium alpha-beryllium sources surrounded by lead and paraffin with a carbon-shielded detector slot in between. The neutrons are slowed down by the shielding materials before reaching the slot. The thermal-neutron flux in this slot has been calibrated by absolute counting of the boron-10 (n,α) reaction, the thermal-neutron cross section for this reaction being well known. From observations of the count rate in a proportional counter or pulse ionization chamber containing a known amout of B^{10}, the thermal-neutron flux can be determined. The NBS standard thermal-neutron flux is known to within about 2 percent. Investigations are presently underway, aimed at an independent calibration of this flux by beta-gamma coincidence counting of gold-198. Unknown fluxes are calibrated against the standard by activating foils in both.

Neutron Detection and Neutron Dosimetry

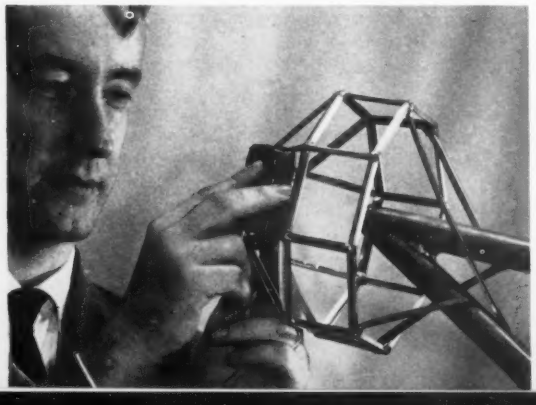
The detection of neutrons in the presence of gamma rays, or of gamma rays in the presence of neutrons, is often a difficult problem. The most satisfactory method for analyzing such mixed radiation employs a pair of detectors, one sensitive to neutrons only, and the other sensitive to gamma rays only. Mixed-radiation dosimetry, however, is even more difficult because detectors in order to read dose must have a specific dependence upon neutron or gamma-ray energy. Instruments for neutron dosimetry may be designed to respond in two ways. The first way, which is most important for measuring the relatively hazardous fast neutrons, is to make the response of the instrument proportional to energy absorbed per gram in soft tissue.[4] Such an instrument may be calibrated in rads for tissue, where 1 rad is 100 ergs/g. Other neutron radiation instruments have a response which is inversely proportional to maximum permissible neutron fluxes. The reading of such an instrument gives a direct indication of radiation hazard, valid for all neutron energies up to 20 Mev.

Fast-neutron detectors consisting of zinc sulfide grains dispersed in a hydrogenous plastic "button" have been widely used because of their excellent gamma-ray discrimination. Recent work at the Bureau has demonstrated that many other kinds of phosphor material may be incorporated in buttons, yielding simple, reliable detectors with good gamma-ray discrimination. For example, plastic-phosphor matrix detectors using organic-plastic phosphors have a much faster response time than other neutron detectors which also provide good gamma-ray discrimination.[5] By adding a material such as boron or lithium, which have large probabilities of undergoing an (n,α) reaction, to a button detector, it may be possible to develop a simple neutron survey meter with proper energy response for dosimetry from 20 Mev down. Other advantages provided by the use of inorganic phosphors, such as potassium iodide and sodium iodide, are greater button transparency and higher efficiency. Development of fast-neutron survey meters based on this generalized plastic-phosphor matrix principle is planned by the Navy Bureau of Ships.

Photographic film is widely used as a gamma-ray dosimeter in mixed neutron and gamma-ray fields. Although the film has a low neutron sensitivity, the extent of its neutron response must be accurately known for the correct interpretation of experiments such as radiobiological studies. A very pure neutron field must therefore be produced so that gamma radiation will not be present to mask the effects of the neutrons. To provide such a field, neutrons from the H^2 (d,n) He^3 reaction (often called the $d+d$ reaction) are used, which are initially free of gamma radiation. Inelastic scattering, which is responsible for gamma-ray production, is largely eliminated by the use of a specially-constructed light-weight aluminum target assembly with a Van de Graaff accelerator.

To measure the small gamma-ray contamination of the radiation field, a neutron-insensitive gamma-ray dosimeter was developed.[6] This instrument is a helium-CO_2 gas-filled counter with graphite-lined aluminum walls. Heavy-particle recoils caused by neutrons produce large pulses, which are discarded in the electronic data recording system. Small pulses, produced by secondary electrons ejected from the walls or gas, represent true gamma-ray sensitivity. Radiation fields in which the fast neutron dose is at least 100 times the measured gamma-ray dose have been measured with this arrangement.

Film badges are mounted on this metal framework surrounding an accelerator target to evaluate neutron sensitivity.

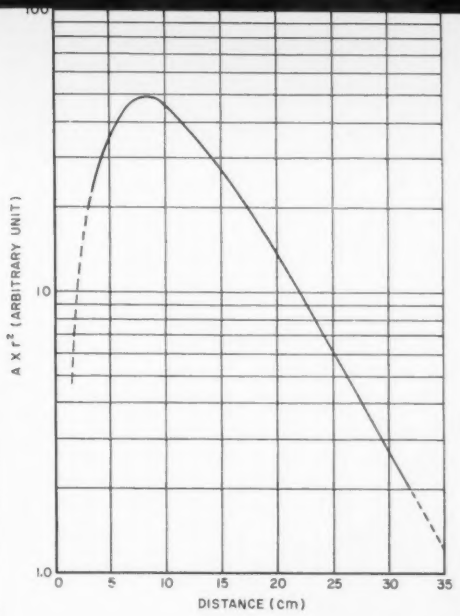


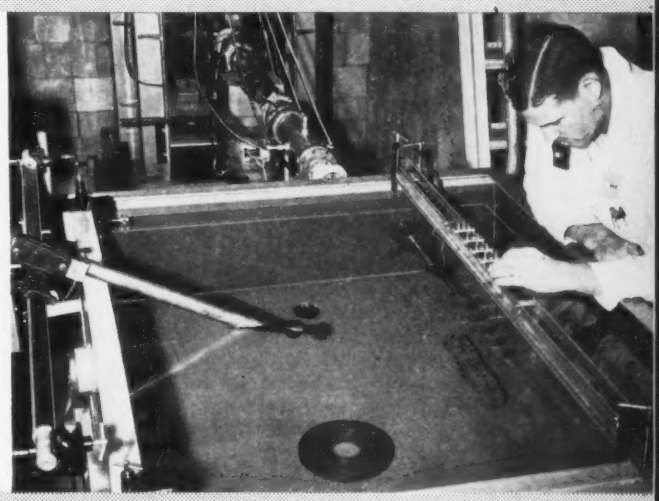
Neutron Penetration and Diffusion

The program of studies on neutron penetration and diffusion was instituted in 1952, when large discrepancies were noted between theoretical calculations of neutron penetration and experimental measurements. A 20-percent difference between experimental measurements of fission-neutron age in water and calculations of the same quantity caused a great deal of concern. By the use of neutrons which are nearly monoenergetic and whose energies are well known from classical mechanics, an independent critical check of slowing-down theory was conducted by the Bureau for the Atomic Energy Commission. Complementary calculations of neutron penetration and diffusion are now being carried out in the Bureau's Radiation Theory Section.

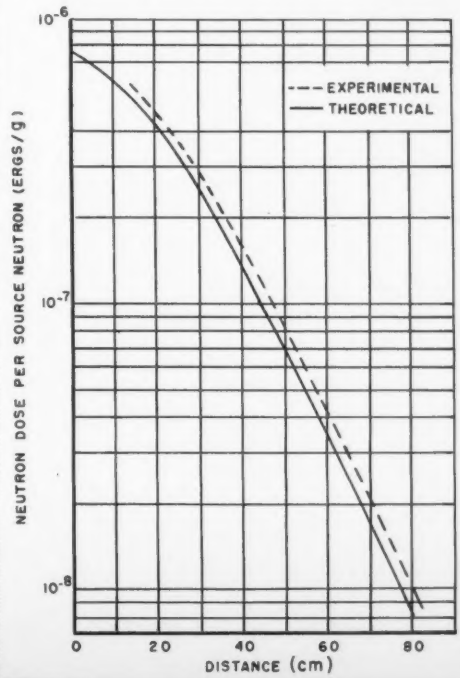
The experiments conducted used neutrons from the target of a 2-Mev Van de Graaff accelerator produced by the H^2 (d,n) He^3 and the H^3 (d,n) He^4 (or $d+t$) reaction. The measurements were usually carried out with water as the shield because of experimental convenience and uniformity, and the completeness of theoretical data for this substance.

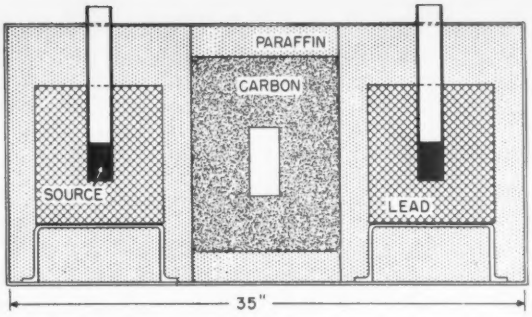
In this work, three kinds of detectors have been used: Thermal neutron detectors, such as indium foils and boron counters; indium resonance neutron detectors, which are indium foils enclosed in cadmium to shield out thermal neutrons; and a polyethylene-lined ethylene-gas-filled proportional counter which acts as a fast-neutron dosimeter with a response very nearly proportional to that of tissue. The measurements with thermal-neutron detectors and indium-resonance neutron detectors are of particular interest to the reactor designer who needs to know how far fission





Above: **A function of activity produced in indium foils by 2- to 3-Mev indium-resonance neutrons from the d+d reaction plotted against distance in water. Measurements were made at 90° to the incident neutron beam which has an energy of 250 kev.** *Below:* **A comparison between experimental data and theoretical calculation of neutron penetration in water. Dose measurement for 14.1-Mev neutrons are plotted against distance in water.** *Right:* **Experimental arrangement for determining neutron penetration in water. This experiment measures the "age", or one-sixth of the mean square of the crow-flight distance that fast neutrons travel while being slowed to a particular energy.**





Standard thermal neutron flux geometry used to calibrate the fluxes of unknown sources. This geometry consists of two symmetrically placed radium alpha-beryllium sources surrounded by lead and paraffin with a carbon-shielded detector slot between.

neutrons from the reactor fuel elements travel while slowing down to energies where they may be captured by uranium and produce fission in the next fuel element.

The age (one-sixth of the mean square crow-flight distance for neutron slowing down) has been measured for 14.1-Mev neutrons from the H^3 (d,n) He^4 reaction,[7] and for 2- to 3-Mev neutrons from the H^2 (d,n) He^3 reaction.[8] The latter experiment is a more interesting check on theory, as the neutron cross sections used in the theoretical calculations are well known and the source of neutron energies lies near the average of the neutron energies for a fission-neutron source. A recent calculation [9] is in excellent agreement with the H^2 (d,n) He^3 neutron measurement made by the Bureau.

A fast-neutron dose measurement has been made with the very penetrating radiation from a 14.1-Mev neutron source. Besides providing data basic to nuclear reactor shielding theories, the results of this kind of experiment are directly applicable to shielding design for controlled thermonuclear devices.

Neutron Cross Sections

Although further experimental checks of neutron penetration calculations are necessary and desirable, the present state of agreement between experiments and calculations is generally satisfactory. Perhaps the most useful experimental information that can now be provided for penetration calculations is neutron cross-section data. Although total neutron cross sections are widely known for most elements, very little information is available on differential neutron cross sections and angular distributions. Therefore, the program will be directed more and more toward the measurement of these fundamental neutron cross sections.

Time-of-flight equipment suitable for these measurements is now being prepared. This equipment measures neutron energies by observing the flight time for a neutron to travel a given distance. Times are measured with a resolution of about 2 mμsec (2×10^{-9} sec). Neutrons are detected in plastic scintillators followed by 14-stage photomultipliers. The short time interval is converted to a pulse height and recorded in a 256-channel pulse-height analyzer. These experiments will be performed with the Van de Graaff accelerator in a low-scatter building which has been recently constructed for this purpose. This building has thin metal walls and a grating floor to insure that the neutrons observed in experiments originate from the sources and the neutron scatterer, and not from the walls of the room.

The neutron, because of its lack of electrical charge, is a particularly interesting particle for investigating the nucleus. Among experimental measurements to be emphasized in the future, therefore, are determinations of angular distributions of neutrons scattered by nuclei and measurements of elastic and inelastic neutron scattering. This work is in line with the present shift of emphasis toward the provision of fundamental neutron interaction data.

Other neutron research at the Bureau is carried on in the High Energy Radiation Section. Here photoneutron production cross sections are measured to provide data on various nuclei. (See, *Shape of the Atomic Nucleus*, p. 45 this issue.)

[1] Neutron physics section established, *Tech. News Bul.* **41,** *75 (1957).* Absolute calibration of the NBS standard thermal neutron density, *by J. A. de Juren and Hyman Rosenwasser, J. Research NBS* **52,** *93 (1954) RP2477.*

[2] Neutron calibration service, *Tech. News Bul.* **41,** *131 (1957).* Standards for neutron flux measurement and neutron dosimetry, *by R. S. Caswell, J. Chin, and E. R. Mosburg, Jr., Proc. of the Second International Conference on the Peaceful Uses of Atomic Energy (in press).*

[3] Absolute calibration of the national photoneutron standard, *Tech. News Bul.* **39,** *140 (1955).* Absolute calibration of the National Bureau of Standards photoneutron standard, *by J. A. de Juren, D. W. Padgett and L. F. Curtiss, Part I, J. Research NBS* **55,** *63 (1955) RP2605; Part II J. Research NBS* **55,** *311 (1955) RP2635.*

[4] Protection against neutron radiation up to 30 million electron volts, *NBS Handbook* **63** *(1957). Available*

Tank of manganese sulfate used as the moderator in calibrations of the national standard photoneutron source. The number of manganese atoms activated is measured by counting of the induced beta-ray activity of the manganese.

from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 40 cents.

[6] Improved method for neutron detection, *Tech. News Bul.* **42,** *186 (Sept. 1958).* Phosphor-plastic matrix for fast neutron detection, *by B. Brown and E. B. Hooper, Jr., Nucleonics* **16,** *96 (1958).*

[7] Neutron-insensitive gamma-ray dosimeter, *by R. S. Caswell, Radiology* **68,** *101 (1957).*

[7] Attenuation of 14.1-Mev neutrons in water, *by R. S. Caswell, R. F. Gabbard, D. W. Padgett, and W. P. Doering, Nuclear Sci. and Eng.* **2,** *143 (1957).*

[8] Age to indium resonance for D–D neutrons in water, *V. Spiegal, Jr., D. W. Oliver, and R. S. Caswell, Nuclear Sci. and Eng.* **4,** *546 (1958).*

[9] *Private Communication, C. R. Mullin, Knolls Atomic Power Laboratory, Schenectady, N.Y.*

CHANGES IN ASPHALT DURING PROCESSING

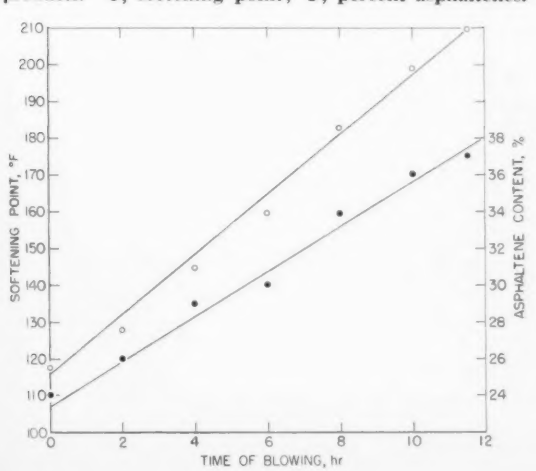
THE BUREAU, in cooperation with the Asphalt Roofing Industry Bureau, has been studying the changes that occur when asphalt flux is converted, by blowing, into roofing-grade materials.[1] Samples for chemical and physical analysis were taken at 2-hr intervals during the conversion period. These samples were used to determine the distribution of components and to investigate the properties of the flux and its components. The work was carried out by L. R. Kleinschmidt and H. R. Snoke of the floor, roof, and wall coverings laboratory as part of a study of the constitution and degradation of asphalt.

Asphalt fluxes are the residues from refinery processes that remove the lower boiling fractions from petroleum. Asphalts used in the manufacture of roofing materials are made by blowing air through these fluxes at elevated temperatures. The softening point of the asphalt products increases and the ductility and penetration decrease the longer the material is blown.

In the experimental procedure, a 50-ton charge of a typical asphalt was blown at 375° to 400° F for 11¾ hr, at a rate of 500 ft³ of air per minute. Samples were taken at 2-hr intervals and at the end of the operation. Standard test methods of the American Society for Testing Materials were followed to find the softening point, penetration, ductility, viscosity, sulfur content, iodine number, and coke residue of each sample. Chemical procedures were used to separate the asphalt into its component resins, oils, asphaltenes, and resultant asphalt products. Refractive indices of the oily constituents were measured on an Abbe-type refractometer.

Results show that during the blowing operation, the softening point of the asphalt products increased linearly with time. The penetration and ductility decreased rapidly during the first 6 hr of blowing, but changed relatively little thereafter. There was little change in the percentage of asphaltic resins, although the amount of asphaltenes that were recovered by the chemical separation process increased linearly with time.

Softening point and percentage of asphaltenes in asphalt products. O, softening point; ●, percent asphaltenes.



Component distibution in asphalt products

Time of blowing, hr	0	2	4	6	8	10	11¾
Components:							
Asphaltenes, %	24	26	29	30	34	36	37
Asphaltic resins, %	17	15	14	14	13	13	13
Total oily constituents, %	58	58	56	56	53	51	49
Total recovery, %	99	99	99	100	100	100	99

The amounts of oily constituents (dark oils and water-white oils) decreased as blowing proceeded. Significant differences in the physical characteristics of the total oily constituents were observed: Both refractive index and viscosity decreased. However, the relative percentages, refractive indices, and viscosities of the water-white oils remained essentially constant during the conversion.

The percentage of coke residue of the asphaltenes, asphaltic resins, total oily constituents, and asphalt products differed greatly. The slight differences in the iodine value between the flux and the blown product, and between the components separated from these two materials, showed that no marked changes occurred in the halogen reactivity of the flux during blowing. The sulfur content of the flux and of the asphalt blown 11¾ hr were the same, showing that no sulfur was lost during the blowing operation.

[1] *For further technical information, see* Changes in the properties of an asphalt during the blowing operation, *by L. R. Kleinschmidt and H. R. Snoke, J. Research NBS* **60,** *159 (1958) RP2835.*

FOURTH INTERNATIONAL SYMPOSIUM ON FREE RADICAL STABILIZATION

THE FOURTH International Symposium on Free Radical Stabilization will be held at the Bureau, August 31 to September 2, 1959. In accordance with the theme of the meeting, "Trapped Radicals at Low Temperatures", emphasis will be placed on the properties of solids containing trapped radicals, and the chemical and physical interactions involving trapped radicals at low temperatures.

Activities tentatively scheduled for the first day of the symposium include a discussion of "The Organization and Aims of the NBS Free Radicals Program", a session on "Low Temperature Chemistry", and a banquet in the evening. On the following day, "Methods of Production of Trapped Radicals and Physical Properties of Radical-Trapping Solids", and "Identity and Concentrations of Trapped Radicals" will be discussed. The evening activities will include a round table discussion of "Future Trends in Free Radical Stabilization". The final session of the symposium, "Interaction of Free Radicals with Solids", will be held the morning of September 2. That afternoon, tours of the laboratories of the Bureau's free radicals program will be conducted.

In addition to the conducted tours, informal visits to the free radicals laboratories may be arranged for the two days immediately following the symposium. These visits should be planned in advance by writing the National Bureau of Standards.

Although the program of presented papers is for the most part already complete, time has been set aside in the various discussion periods for brief reports. These short communications will be listed in the program, but need not be submitted in manuscript form. Notification of the nature of a proposed communication should be made before August 1.

Further information can be obtained by writing Dr. A. M. Bass, National Bureau of Standards, Washington 25, D.C. Forms for preregistration must be requested before March 25.

DIGGES RECEIVES BURGESS AWARD

THOMAS G. DIGGES, Assistant Chief of the Metallurgy Division and Chief of the Thermal Metallurgy Section, has become the first recipient of the George Kimball Burgess Memorial Award of the Washington Chapter, American Society for Metals. Dr. Burgess, who was Director of the National Bureau of Standards from 1923 to 1932, served as President of the American Society for Metals in 1924.

Mr. Digges was cited for "outstanding research on boron in steel and high temperature metallurgy" and his "achievements in research administration".

Since joining the Bureau in 1920, Mr. Digges has done extensive work in the fields of machinability of metals and performance of tool steels, hardenability of high-purity iron-carbon alloys, ductility of metals at high and low temperatures, and the effects of boron on the hardenability of steels. As a result of his and others' work, many low alloy and plain carbon steels are now treated with a small amount of boron to increase their hardenability, thus conserving other alloying agents.

Born near Warrenton, Virginia, in 1897, Mr. Digges attended Virginia Polytechnic Institute and graduated from George Washington University in 1926 with a B.S. degree in physics. He is the author of over 50 scientific papers, and has received two certificates of appreciation for work done during World War II, the U.S. Department of Commerce Award for Meritorious Service, and the American Society for Metals Gold Medal, for service as a trustee.

Mr. Digges is a member of the Washington Academy of Sciences, the American Society for Metals, the American Institute of Mining and Metallurgical Engineers, the American Society for Testing Materials, and he has served in various capacities with the Washington Chapter of the American Society for Metals.

Mechanism of Stress-Corrosion Cracking

A CLEARER UNDERSTANDING of the mechanism of stress-corrosion cracking is the objective of a current research program sponsored jointly by the Corrosion Research Council and the Bureau. As part of this work, Hugh L. Logan of the corrosion laboratory recently completed a stress-corrosion study [1] of AZ31B magnesium alloy (aluminum 3%, zinc 1%).

The stress-corrosion cracking of metals is recognized as a serious problem in today's economy. Stress-corrosion cracking of brass ("season cracking") has long been known to be a potential cause of failure in brass articles formed by spinning or deep drawing and not subsequently annealed. Many failures of riveted steel boilers have been attributed to stress corrosion, known in this instance as "caustic embrittlement". The fabrication of steel vessels by welding has reduced, but by no means eliminated, stress-corrosion cracking in low-carbon and low-alloy steels.

Metallurgists and management in the chemical and petrochemical industries have learned in the past few years that many if not most of the "thousands of leaks" that develop in stainless steel equipment used in those industries are in reality stress-corrosion cracks. Until such time as the mechanism of stress-corrosion cracking is completely understood, methods of mitigation are largely empirical.

Most investigators in the field are agreed that stress-corrosion cracking is in part, at least, an electrochemical process. There is wide disagreement, however, as to just how much of the mechanism is electrochemical.

Certain magnesium alloys are ideal for a mechanistic study. Earlier work [2] had shown that in the corrodent used in the laboratory (3.5% NaCl+2.0% K_2CrO_4) there was a threshold stress for each magnesium alloy. Specimens exposed above this stress failed in a few minutes; below this stress they did not fail in many hours. Hence, many data were readily obtained.

In most of the present work, the specimen was placed in a cell and the corrodent was added before the stress was applied. It was found that while the major strain occurred with the application of the stress to the specimen, the specimen continued to extend, but at a diminishing rate, for a considerable time after the stress was applied. The calculation of many strain rates, determined for specimens stressed above, at, and below the threshold stress, showed that there was a critical strain rate, $500 \pm 100 \times 10^{-6}$ in./in./min as determined 1 minute after the stress was applied. If this rate was exceeded, early failure by stress-corrosion cracking occurred. If the strain rate was less than this value, failure did not occur and the specimen showed little if any general corrosion. Earlier work [3] had shown that plastic extension of this alloy ruptured the protective film on it, exposing a film-free surface that was anodic to the normal surface and hence would be attacked by an electrochemical process in an electrolyte. It was also shown that the film tended to re-form. It was concluded from the present data that if the specimen was extending at an average strain rate in excess of 500×10^{-6} in./in./min there would be certain areas on which the strain rate would exceed the rate of film repair; these areas would be anodic to the filmed surface and stress-corrosion cracks would develop. At lower strain rates, a protective film would form on the metal and there would be no corrosive attack.

Above: **Apparatus used in studying stress-corrosion cracking. A magnesium alloy specimen inside the cell (left center) is stressed. A corrosive medium can be added before or after the stress is applied. The distance through which the specimen extends is indicated by a dial gage (right).**

Left: **Magnesium alloy specimen inside a stress-corrosion cell. A corrosive medium is added to the cell and its effects on the specimens are studied.** ***Right:*** **Stress-corrosion cracking in a magnesium alloy specimen exposed to the weather.**

It was assumed that if the specimen was stressed and the strain rate had decreased below the critical value before the corrodent was added, the specimen would not fail. Experimentally it was found that in this case the critical strain rate was much lower than that given above. This apparent contradiction in the data was explained when it was noted that there was a marked increase in the strain rate on the addition of the corrodent. This fact also suggested an explanation for a phenomenon previously noted in weather exposure work, namely, that most cracking and failures of specimens were found following rain. If the corrosion products dissolved in rain water had the same effect as the corrodent in the laboratory, increased strain would exist over microscopic lengths of the specimen. Then, if the critical strain rate was exceeded, stress-corrosion cracking would occur.

Deviations from the normal strain rate-time curves were found to indicate the formation of stress-corrosion cracks. Hence, it was possible to apply cathodic protection to specimens after stress-corrosion cracks had developed. Cathodic protection stopped stress-corrosion cracking, even after cracks had penetrated an appreciable distance into the metal, by polarizing the entire specimen to the potential of the anodic areas. With removal of cathodic protection, the specimen was depolarized immediately and failure by stress-corrosion cracking occurred within a few minutes.

These data indicate that the inception and propagation of stress-corrosion cracking, in this alloy, is primarily an electrochemical process.

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[1] *For further technical details, see* Mechanism of stress-corrosion cracking in the AZ31B magnesium alloy, *by Hugh L. Logan, J. Research NBS,* **60,** *503 (1958) RP2919.*

[2] Stress corrosion of wrought magnesium alloys, *by Hugh L. Logan and Harold Hessing, J. Research NBS,* **44,** *233 (1950) RP2074.*

[3] Film-rupture mechanism of stress corrosion, *by Hugh L. Logan, J. Research NBS,* **48,** *99 (1952) RP2291.*

RECENT BOOKS BY NBS AUTHORS

RECENT BOOKS by staff members reflect Bureau activities in several fields—electronics, digital computers, radiological measurements, quantum theory, and radiation physics. Some of these works are at the frontiers of their subjects, others organize considerable bodies of knowledge in usable form, and still others undertake the task of making complex matters understandable to greater numbers of people.

C. L. Page, Consultant to the Director, calling on his experience in teaching and research, attempts in *The Algebra of Electronics* to show how relatively elementary mathematics can clarify many of the mysteries of electronic circuits. In *Electronic Digital Computers,* F. L. Alt, assistant chief of the applied mathematics laboratories, has prepared a guide to the high-speed computer field for scientists and engineers who originate problems for computers to solve. *Radiation Protection,* a summary of present knowledge, is addressed to the growing numbers of scientists, engineers, and physicians, architects and health officials, and others concerned with minimizing radiation hazards: its chief authors are Carl B. Braestrup [1] and H. O. Wyckoff, chief of the radiation physics laboratory.

U. Fano, chief of the radiation theory group, appears as coauthor of three works. *Basic Physics of Atoms and Molecules* was written with his wife, L. Fano, of the thermodynamics laboratory; the fruit of many years of reflection, it attempts to make the concepts of quantum theory intelligible to wider groups of scientific workers. *Penetration and Diffusion of X-Rays,* written with his colleagues L. V. Spencer and M. J. Berger, is a detailed technical review of its field;

invitation to prepare this monograph for the *Encyclopedia of Physics* came in recognition of the Bureau's contributions to the subject.[2] *Irreducible Tensorial Sets*, written with Giulio Racah,[3] is concerned with a new branch of mathematics used in quantum mechanics.

Further description of the aims and contents of these books is given below.

Electronics

The Algebra of Electronics [4] is intended for self-study by technicians or by scientists in other fields who wish to understand the basic principles used in the operation and design of electronic circuits. Developing the essentials of the subject in progressive fashion, the book aims to extract a maximum of information from the judicious use of elementary mathematical analysis. However, though exploiting the clarifying power of mathematical analysis, the treatment also contains many practical hints, and the reader's attention is constantly called to the limitations of simplified mathematical models.

Much of the mathematics used is developed as needed, so that sections are included on linear equations and determinants, complex numbers with applications to linear differential equations, hyperbolic functions, and Fourier series. Sparing use is made of the calculus, and recourse is had to graphical methods for nonlinear problems. Some of the topics given special attention are: The topological approach to networks, derivation of network theorems, development of circuit behavior of capacitors and inductors from fundamentals, resonance, ideal and practical transformers, impedance matching and the effects of mismatch, amplifiers and feedback, noise, distortion, and modulation.

Digital Computers

Though it might serve as an introductory survey for anyone beginning the study of computers, *Electronic Digital Computers* [5] is addressed primarily to those who have occasion to call on the digital computer for assistance in computational problems, particularly to scientists and engineers. Emphasis is on the way computers function; engineering features are touched on only to the extent needed in judging the suitability of machines for particular problems. The exposition is intended to enable prospective users to discuss their problems intelligently with computer experts, to avoid common pitfalls, and, in general, to feel "at home" in the digital computer field.

Part 1 of the book outlines the steps in preparing a problem for a computer and gives a preliminary sketch of the major topics in parts 2, 3, and 4: Functions and components, coding and programing, and problem analysis. The principal coding systems are explained in the detail needed to exhibit the peculiarities and advantages of each; and the discussion of programing describes the processes involved in preparing a flow chart of computer operations. Under "Problem Analysis", there is consideration of rounding errors, ways of checking computations, and commonly used methods for dealing with the evaluation of explicit functions, differentiation and integration, ordinary and partial differential equations, and algebraic equations. Part 5 describes representative computer applications, mainly from science and engineering, indicating the machine characteristics required for their solution and stating criteria for matching machines to problems; there is also a discussion of the requirements for establishing one's own computation laboratory. Frequent references to the literature direct the reader to further information on particular topics.

Radiation Protection

Although the theory of radiation physics is now well established, the authors of *Radiation Protection* [6] note that its application to protection problems has not been adequately covered in an integrated treatment. This they have attempted to do "in a manner understandable to professional people who are not specialists in this field." The number of such persons, already large, is steadily increasing as more and more uses for radiation are found in medicine and industry. To meet the hazards that may arise, knowledge is needed not only on specific methods and instruments, but on the nature of radiations, how they are produced and measured, their biological effects, and the many different factors that must be weighed in handling any particular problem.

The chapter on biological effects was contributed by Titus C. Evans [7] and S. Allen Lough,[8] the chapter on nonsealed radioactive sources, also by S. Allen Lough, and the one on atmospheric contamination by Merrill Eisenbud.[9] Topics discussed in the other nine chapters include calibration of radiation detectors, shielding techniques, medical and industrial X-ray installations (two chapters), megavolt installations, radiation surveys, and personnel monitoring. Data for shielding design are given in tables and charts in the appendixes, and the text is documented by references to available special studies.

Nuclear reactor problems have been omitted because they would require rather special treatment and are well covered in the literature; but the hazards in applications of their radioactive products are discussed in some detail. Also, no specific reference is made to radiological aspects of defense against nuclear weapons, though most of the chapters are applicable in the training of higher echelon defense groups.

Quantum Theory

Basic Physics of Atoms and Molecules [10] offers a qualitative picture of the properties of atoms and molecules for the use primarily of research workers in the natural sciences. The authors remark that "quantum physics is no more abstract than Newtonian mechanics, but it took a long time before Newtonian mechanics

appeared as plausible as it does today. This book attempts to make quantum physics a little more plausible to a few more people."

The general plan is to develop ideas and establish laws through inductive analysis of experiments and only then to introduce the mathematical symbols and to formulate the equations and calculations that represent them. The experiments were selected for the directness with which they reveal characteristic properties of atomic systems, that is, for their pedagogical value rather than for their actual historical role in the development of the subject. Through the examination of these experiments, the fundamental concepts of quantum physics are presented in chapters 6 to 9 and are elaborated in the remaining chapters (10 to 22) as they are applied to basic problems of atomic mechanics. Ten appendixes contain auxiliary discussion and mathematical notes; one of them outlines an introduction to matrix and operator methods.

X-ray Penetration

Penetration and Diffusion of X-rays [11] is a comprehensive review of a field which is perhaps unique for the intimate combination of modern analytical and numerical methods used in attacking its problems. The review deals primarily with X-ray photons in the range from about 20 kev (below which the situation is dominated by photoelectric absorption) up to levels at which cascade shower processes predominate: the high-energy limit varies from about 10 Mev for heavy elements to above 100 Mev for light elements. The treatment is thus confined mostly to conditions in which the penetration of corpuscular secondaries and their bremmstrahlung has a minor influence.

Of the five main parts of the monograph, part A surveys what is known on the elementary processes, emphasizing aspects most relevant to the study of multiple processes; and the theory of multiple processes is then constructed in part B. Part C reports on the procedures and results of numerous calculations of X-ray distributions, including exploratory studies of a wide range of problems and systematic tabulations for some. The main theoretical developments apply only to infinite homogeneous media, while the effects of boundaries and other inhomogeneities have been studied by Monte Carlo (random sampling) calculations. The latter studies, which have now yielded a fairly substantial body of results, are reviewed in part D. Experimental results are given together with the appropriate theory, but when the experiments do not relate directly to existing calculations they are reported separately in part E. This last part also discusses briefly those aspects of experimental technique that are particularly relevant to observation of X-ray distributions.

Tensorial Sets

In *Irreducible Tensorial Sets* [12] the authors summarize their efforts thus far to develop a unified treatment of a generalization of vector and tensor algebra that has grown up to handle certain problems in atomic physics (coupling and recoupling of angular momenta). A "tensorial set" may consist of various sorts of elements, such as tensor components or states of an atomic system, provided they have common transformation properties when the coordinate system changes orientation. When such sets are "irreducible", i.e., when they cannot be resolved into subsets with separate linear transformations, equations among them take their simplest form. Then, by using a single symbol for an entire irreducible set, the advantages of vector algebra (compact formulations) are combined with the wider scope of tensor algebra.

The first portion of the book (part A) develops the algebra of the new entities by using a type of multiplication which is a generalization of the ordinary vector product and of the addition of angular momenta in atomic physics. A newer result concerns certain algebraic identities ("recoupling transformations") relating products constructed in different ways; these are somewhat analogous to the vector equation

$$(a\times b)\times c=(a\cdot c)b-(b\cdot c)a.$$

Part B reviews a number of applications to different branches of atomic and nuclear physics; the applications are grouped according to type of theoretical problem and to technique used in the solution. To avoid interrupting the main development of concepts and techniques, specialized material has been placed in 10 short appendixes.

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[1] *Director, Physics Laboratory, Francis Delafield Hospital; Associate, Department of Radiology, Columbia University; member, Executive Committee, National Committee on Radiation Protection and Measurements.*

[2] *See,* Penetration and diffusion of gamma rays, *NBS Tech. News Bul.* **40**, *144 (1956).*

[3] *Professor of Theoretical Physics, Hebrew University, Jerusalem.*

[4] The algebra of electronics, *by C. L. Page, 258 p (D. Van Nostrand Co., N.Y., 1958).*

[5] Electronic digital computers: their use in science and engineering, *by F. L. Alt, 336 p (Academic Press Inc., N.Y., 1958).*

[6] Radiation protection, *by C. B. Braestrup and H. O. Wyckoff, with contributions by M. Eisenbud, T. C. Evans, and S. A. Lough, and Foreword by L. S. Taylor, 361 p (C. C. Thomas Publisher, Springfield, Illinois, 1958).*

[7] *Director, Radiation Research Laboratory, College of Medicine, State University of Iowa; Managing Editor, Radiation Research.*

[8] *Director, Health and Safety Laboratory, N.Y. Operations Office, U.S. Atomic Energy Commission; Adjunct Associate Professor of Industrial Medicine, New York University Post-Graduate School of Medicine.*

[9] *Manager, N.Y. Operations Office, U.S. Atomic Energy Commission; Adjunct Professor of Industrial Medicine, New York University Post-Graduate School of Medicine.*

[10] Basic physics of atoms and molecules, *by U. Fano and L. Fano, about 410 p. (John Wiley and Sons, N.Y., in press).*

[11] Penetration and diffusion of X-rays, *by U. Fano, L. V. Spencer, and M. J. Berger. This will constitute a major part of volume XXXVIII/II of the Encyclopedia of Physics/Handbuch der Physik, edited by J. Flugge, (Springer-Verlag, Berlin,* in press).

[12] Irreducible Tensorial Sets, *by U. Fano and G. Racah, 171 p. (Academic Press Inc., N.Y., 1959).*

Publications of the National Bureau of Standards

Periodicals

Journal of Research of the National Bureau of Standards, Volume **62,** No. 2, February 1959 (RP2929 to RP2934 incl.) 60 cents.

Technical News Bulletin, Volume **43,** No. 2, February 1959. 15 cents. Annual subscription $1.50, 75 cents additional for foreign mailing.

Basic Radio Propagation Predictions for May 1959. Three months in advance. CRPL–D174. Issued February 1959. 10 cents. Annual subscription $1.00, 50 cents additional for foreign mailing.

Research Papers

Journal of Research, Volume **62,** *No. 2, February 1959. 60* cents.

RP2929. Determination of niobium and tantalum in titanium-base alloys. John L. Hague and Lawrence A. Machlan.

RP2930. Properties of zinc borosilicate glasses. Edgar H. Hamilton, Roy M. Wexler, and Joseph M. Nivert, Jr.

RP2931. Design and performance of a block-type osmometer. Donald McIntyre, G. C. Doderer, and James O'Mara.

RP2932. Heat of formation of titanium tetrabromide. Raymond A. Nelson, Walter H. Johnson, and Edward J. Prosen.

RP2933. Adsorption of polyesters on glass, silica, and alumina. Robert R. Stromberg, Alan R. Quasius, Samuel D. Toner, and Midgett S. Parker.

RP2934. Theory of the effect of drag on orbital inclination of an earth satellite. John P. Vinti.

Circulars

C598. Techniques for accurate measurement of antenna gain. H. V. Cottony. 15 cents.

C563 (1st Supplement). Periodicals and serials received in the library of the National Bureau of Standards. Natalie J. Hopper and Hilda W. Reinhart. 10 cents.

Miscellaneous Publications

M226. Research highlights of the National Bureau of Standards. Annual Report, Fiscal Year, 1958. 45 cents.

Publications in Other Journals

Some properties of lightning impulses which produce whistlers (letter). R. A. Helliwell, A. G. Jean, and W. L. Taylor. Proc. I. R. E. **46,** 1760–1762 (Oct. 1958).

A long-distance pulse-propagation experiment on 20.1 megacycles. R. Silberstein. J. Geophys. Research **63,** 445–466 (Sept. 1958).

Behavior of young children under conditions simulating entrapment in refrigerators. Katherine Bain, Marion L. Faegre, and Robert S. Wyly. Pediatrics **22,** No. 4, Part I, 628–647 (Oct. 1958).

Beta-gamma correlations from polarized manganese 52. E. Ambler, R. W. Hayward, D. D. Hoppes, and R. P. Hudson. Phys. Rev. **110,** No. 3, 787–789 (May 1958).

Determination of some compressive properties of human enamel and dentin. John W. Stanford, G. C. Paffenbarger, John W. Kumpula, and W. T. Sweeney. J. Am. Dental Assoc. **57,** 487–495 (Oct. 1958).

Further identities and congruences for the coefficient of modular forms. Morris Newman. Can. J. Math. **10,** 577–586 (1958).

Harmonic generation with ideal rectifiers. Chester H. Page. Proc. I.R.E. **46,** No. 10, 1738–1740 (Oct. 1958).

Piezoelectric effect in indium antimonide. J. H. Wasilik and R. B. Flippen. Phys. Rev. Letters **1,** No. 7, B512L–1–2 (Oct. 1958).

Source of the non-migratable ionic charges developed by portland and high-alumina cements during hydration. Robert G. Pike and Donald Hubbard. Proc. Highway Research Board **37,** 256–270 (1958).

Physics—The electrostatic field and the symmetry of snowflakes. Roald A. Schrack. J. Wash. Acad. Sci. **48,** No. 9, 273–275 (Sept. 1958).

The zirconium—hydrogen system: Some thermodynamic properties from a heat content study. Thomas B. Douglas. J. Am. Chem. Soc. **80,** 5040 (1958).

WWV standard frequency transmissions. D. M. Kerns. (Letter) Proc. I.R.E. **46,** 1881–2 (Nov. 1958).

The patterns of a slot-array antenna on a finite and imperfect ground plane. J. R. Wait and A. M. Conda. L'Onde Electrique **38,** No. 376, 21–29, vis, Proc. Internat. Congress Ultra High Frequency Circuits and Antennas. Paris, Oct. 21–26, 1957 (Aug. 1958).

Liquid-flowmeter calibration techniques. M. R. Shafer and F. W. Ruegg. Trans. ASME **80,** No. 7, 1369–79 (Oct. 1958).

Optical detection of narrow Rb^{87} hyperfine absorption lines. P. L. Bender and E. C. Beaty. Phys. Rev. Letters **1,** No. 9 (1958).

Can the scales of atomic weights and nuclidic masses be unified? Edward Wichers. Phys. Today **12,** No. 1, 28 (1959).

The need for more knowledge of materials in civil engineering. A. T. McPherson. A conference on basic research in civil engineering, Am. Soc. Civil Engrs., p. 20 (Sept. 10–11, 1958).

Narrow hyperfine absorption lines of C_s^{133} in various buffer gases. E. C. Beaty and P. L. Bender. Phys. Rev. **112,** No. 2, 450 (1958).

Photodetachment cross section and the electron affinity of atomic oxygen. Lewis M. Branscomb, David S. Burch, Stephen J. Smith, and Sydney Geltman. Phys. Rev. **111,** No. 2, 504 (1958).

Atomic and molecular negative ions in stellar atmospheres. L. M. Branscomb and B. E. F. Pagel. Monthly Notices Roy. Astron. Soc. **118,** No. 3, 258 (1958).

Photodetachment of O_2^-. D. S. Burch, S. J. Smith, and L. M. Branscomb. Phys. Rev. **112,** 171 (1958).

Calculated calibration points for negative ion appearance potentials. Lewis M. Branscomb. J. Chem. Phys. **29,** No. 2, 452 (1958).

Stable nitrogen isotope analysis by optical spectroscopy. H. P. Broida and M. W. Chapman. Anal. Chem. **30,** 2049 (1958).

Theory of threshold energy dependence of photodetachment of diatomic molecular negative ions. Sydney Geltman. Phys. Rev. **112,** No. 1, 176 (1958).

Temperature dependence of the characteristic energy loss of electrons in aluminum. Lewis B. Leder and L. Marton. Phys. Rev. **112,** No. 2, 341 (1958).

Determination of reducing sugars and reducing end groups in polysaccharides by reaction with carbon-14—labeled cyanide. Joseph D. Moyer and Horace S. Isbell. Anal. Chem. **30,** 1975 (1958).

The system magnesium oxide-germanium dioxide. C. R. Robbins and E. M. Levin. Am. J. Sci. **257,** 63 (1959).

Mutarotation, hydrolysis, and rearrangement reactions of glycosylamines. Horace S. Isbell and Harriet L. Frush. J. Org. Chem. **23,** 1309 (1958).

Isotope effect in oxidation of D-mannitol-2-C^{14} by acetobacter suboxydans. Harriet L. Frush and Lorna J. Tregoning. Science **128,** No. 3324, 597 (1958).

Branched-chain higher sugars. Robert Schaffer and Horace S. Isbell. J. Am. Chem. Soc. **80,** 756 (1958).

Vibration-rotation bands of ammonia. III. The region 3.2–4.3 microns. W. S. Benedict, Earle K. Plyler, and E. D. Tidwell. J. Chem. Phys. **29,** No. 4, 829 (1958).

Errata: Studies in nonequilibrium rate processes. III. The vibrational relaxation of a system of anharmonic oscillators. Norman W. Bazley, Elliott W. Montroll, Robert J. Rubin and Kurt E. Shuler. J. Chem. Phys. **29,** No. 5, 1185 (1958).

Pattern of an antenna on a curved glossy surface. J. R. Wait and A. M. Conda. IRE Trans. Antennas and Propagation **AP–6,** No. 10 (1958).

Cryostat for electron bombardment and electron diffraction work. Erwin M. Horl and L. Marton. Rev. Sci. Instr. **29,** No. 10, 859 (1958).

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LEWIS L. STRAUSS, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. ASTIN, *Director*

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Contents

NBS Publications (*Continued*)

The atmospheric bending of radio waves. B. R. Bean. (Abstract) Congres International sur la Propagation des Ondes Radio-Electriques, Liege (6–11 Octobre 1958).

Observation of vertical-incidence scatter from the ionosphere at 41 Mc/sec. K. L. Bowles. Phys. Rev. Letters **1,** 454 (1958).

Radio propagation research at the National Bureau of Standards. Am. J. Phys. **26,** 628 (1958).

The mean deviation of the Poisson distribution. E. L. Crow. Biometrika **45,** 556 (1958).

Distillation of hydrogen isotopes. T. M. Flynn, K. D. Timmerhaus and D. H. Wetzel. Colorado Engr. **55,** 12–15, 20 (Nov. 1958).

Communication via meteor bursts. G. F. Montgomery. Radio-Electronics **29,** 88 (1958).

Low and medium frequency radio propagation. K. A. Norton. (Abstract) Congres International sur la Propagation des Ondes Radio-Electriques, Liege (6–11 Octobre 1958).

Proposed recommendation on ionospheric vertical soundings after the I.G.Y. (Memo No. 18). A. H. Shapley. Intern. Sci. Radio Union. Inform. Bull. No. **111,** 42 (1958).

World-wide soundings committee: Memorandum 17—Future work. A. H. Shapley. Intern. Sci. Radio Union. Inform. Bull. No. 110, 55 (July–Aug. 1958).

Tropospheric effects on 6-MC pulses. (Letter) R. Silberstein. Proc. I.R.E. **46,** 1968 (1958).

Comparison of phase difference and Doppler shift measurements for studying ionospheric fine structure using earth satellites. (Letter) M. C. Thompson and D. M. Waters. Proc. I.R.E. **46,** 1960 (1958).

Excitation of surface waves on plane and curved impedance boundaries. J. R. Wait. Congres International sur la Propagation des Ondes Radio-Electriques, Liege (6–11 Octobre 1958).

Publications for which a price is indicated are available only from the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. (foreign postage, one-fourth additional). The Technical News Bulletin and Basic Radio Propagation Predictions are available on a 1-, 2-, or 3-year subscription basis, although no reduction in rates can be made. Reprints from outside journals and the NBS Journal of Research may often be obtained directly from the authors.

Patents

(The following patents have recently been granted on NBS inventions and, except as noted, are assigned to the United States of America as represented by the Secretary of Commerce.)

No. 2,852,424. September 16, 1958. Reinforced plastic springs. Frank W. Reinhart, Murray C. Slone, Leon Horn, and Desmond A. George (Army).

No. 2,854,992. October 7, 1958. Flow control apparatus for reaction columns and the like. Clifford A. Hewitt.

No. 2,855,511. October 7, 1958. Biased peaker strip energy control system for betatrons and synchrotrons. Edward R. Saunders, Jr.

No. 2,856,769. October 21, 1958. Torsion testing machine for wire. John A. Bennett and Harry C. Burnett (Army).

No. 2,856,852. October 21, 1958. Proximity fuze. Wilbur S. Hinman, Jr., and Harry Diamond (Navy).

No. 2,857,292. October 21, 1958. Process for applying protective metallic coatings. Dwight G. Moore (Air Force).

No. 2,863,763. December 9, 1958. Ductile and tough high strength steel. Samuel J. Rosenberg and Carolyn R. Irish (Navy).

No. 2,864,695. December 16, 1958. Cobalt-gallium dental alloys. Denton L. Smith and Harold J. Caul (research associates).

No. 2,864,977. December 16, 1958. Plug-in-packages. Richard P. Witt, NBS, and Dana A. Griffin, Communication Measurements Laboratory, Inc.

No. 2,866,948. December 30, 1958. Test circuit for interconnected components. Richard P. Witt (Army).

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